Department of Electrical Engineering

EE323- Communication Systems II

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Outlines

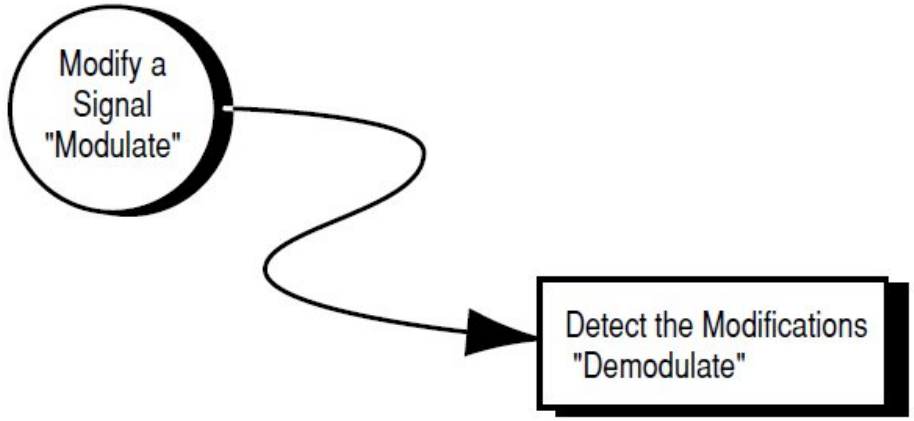
- Introduction
- Sampling Theorem
- Analog Pulse Modulation (APM)
  - Pulse Amplitude (PAM)
  - Pulse Width (PWM)
  - Pulse Position (PPM)
- Digital Pulse Modulation (DPM)
  - Pulse Code Modulation (PCM)
  - Delta Modulation (DM)
- Digital Modulation Techniques: ASK.
- Digital modulation techniques: PSK.
- Digital modulation techniques: FSK.
- Multiplexing Techniques
  - Frequency Division Multiplexing (FDM)
  - Time Division Multiplexing (TDM)

References:

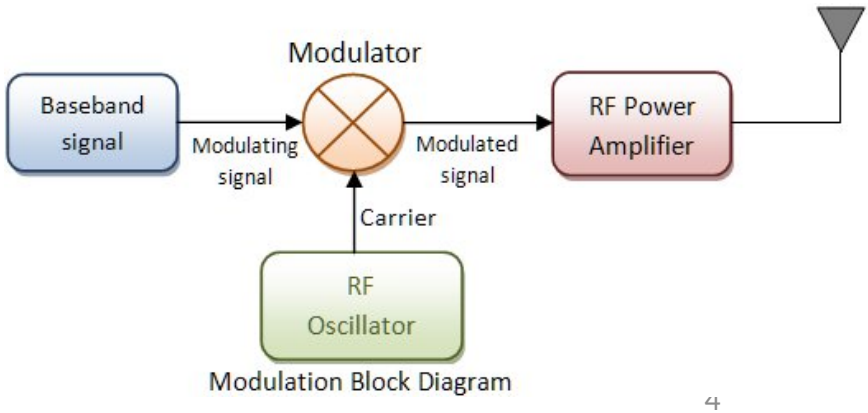
- Lecture Notes
- Modern Digital and Analog Communication Systems, 4th ed.; B.P. Lathi and Zhi Ding; Oxford University Press; 2009.
- Communication Systems Engineering 2nd Ed by John G. Proakis and Masoud Salehi 2002.
- Digital and Analog Communication Systems, 8th Edition by L.W. Couch II, Prentice Hall, 2013.

WHAT IS MODULATION ?

Modulation is the process of changing some property of the information sources/signal into suitable form for transmission through the physical medium/channel. It is performed in the Transmitter by a device called **Modulator**. It is the process of putting information onto a high frequency carrier in a transmitter.



Here baseband signals comes from a audio/video or computer. Baseband signals are also called modulating signal as it modulates carrier signal. carrier signals are high frequency radio waves it generally comes from a radio frequency (RF) oscillators. These two signals are combined in modulator. Modulator takes the instantaneous amplitude of baseband signal and varies amplitude/frequency/phase of carrier signal. Resultant signal is a modulated signal. It goes to an RF-amplifier for signal power boosting and then feed to antenna or a transmission medium.



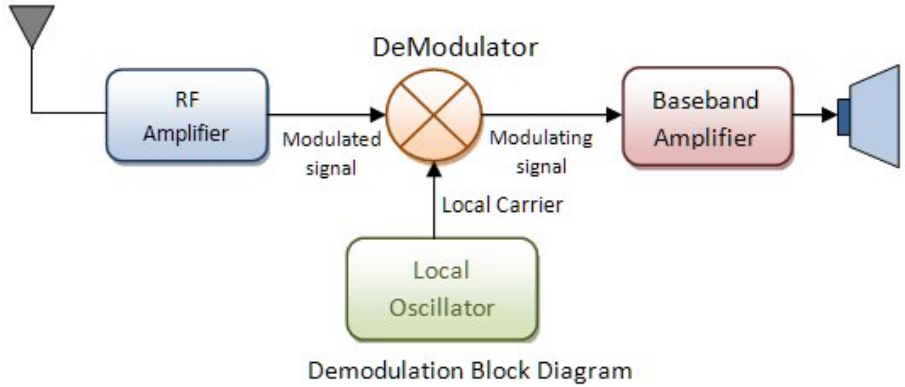
Modulation Block Diagram

Modulation is important because:

- Reduction in the height and size of antenna
- Avoids mixing of signals
- Increases the range of communication
- Multiplexing is possible
- Improves quality of reception

DEMODULATION ?

Demodulation is the opposite process of modulation. It is extracting the original information signal from a modulated carrier signal. It is the process of shifting the passband signal to baseband frequency range at the receiver A radio antenna receives low power signal. A co-axial cable end point can also take as an signal input. An RF amplifier boosts the signal amplitude. Then the signal goes to a demodulator. demodulator does the reverse of modulation and extracts the back band signal from carrier. Then the baseband signal is amplified to feed an audio speaker or video monitor.



Demodulation Block Diagram

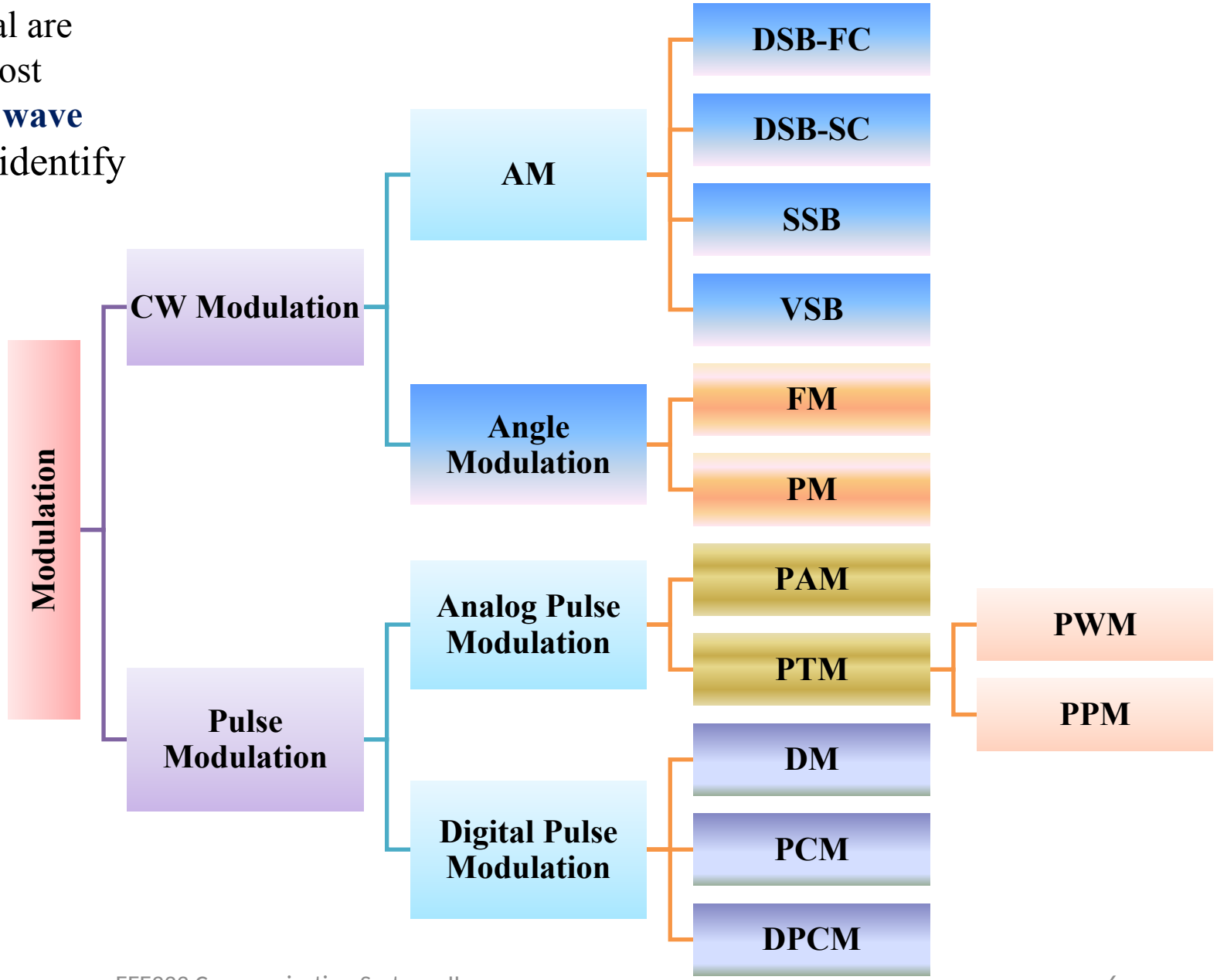
A modem receives signals and also transmits signals thus it does modulation and demodulation at the same time. Thus, the name ***modem*** has been given (***mo***dulation and ***dem***odulation).

Modulation Types

By modulation, characteristics in the carrier signal are changed according to the message signal. Two most common used forms of carriers – **Periodic pulse wave and Sinusoidal wave.** Correspondingly, we identify two main classes of modulation

– **Continuous wave (CW)** which includes
Amplitude Modulation (AM)
Angle Modulation which includes
-Frequency Modulation-(FM)
-Phase Modulation-(PM)
Already given in semester 1.

– **Pulse modulation** which includes
Pulse Analog Modulation : such as pulse amplitude (PAM) and pulse time modulations (PTM) respectively.
Pulse Digital Modulation : Examples are pulse code modulation (PCM) and delta modulation (DM).



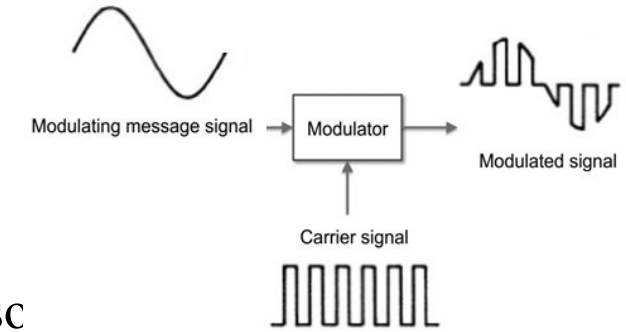
Pulse Modulation

Pulse Modulation, similar to the CW modulation techniques, consists of two signals, which are the carrier and the message modulating signals. However, in Pulse Modulation, **carrier signal is in the form of a pulse signal**. The message signal will modulate the carrier signal to generate pulse-modulated signal.

There are two families of pulse modulation

1 . Analog Pulse Modulation (APM)

2. Digital Pulse Modulation (DPM)



In analog pulse modulation, a periodic pulse train is used as the carrier wave, and sc
each pulse (e.g., **amplitude, duration, or position**) is varied in a continuous manner in accordance with the corresponding sample value of the message signal. Thus, in analog pulse modulation, information is transmitted basically in analog form, but the transmission takes place at discrete times.

In digital pulse modulation, on the other hand, the message signal is represented in a form that is discrete in both time and amplitude, thereby permitting its transmission in digital form as a sequence of coded pulses.

Pulse Modulation

The process of transmitting signals in the form of pulses (discontinuous signals) by using special techniques.

Analog Pulse Modulation

- Pulse Amplitude (PAM)
- Pulse Width (PWM)
- Pulse Position (PPM)

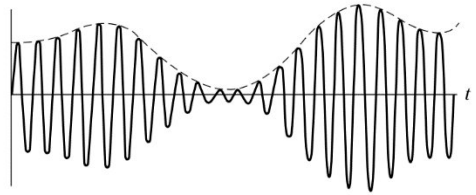
Digital Pulse Modulation

- Pulse Code (PCM)
- Delta (DM)

Advantages of Pulse modulation over CW modulation

✓ Since we transmit the information using a pulse train, we do not need to generate power continuously. Power is transmitted in short bursts.

✓Since, time between two pulses is free, it can be utilized to send samples of other message signals. This is called as Time Division Multiplexing.

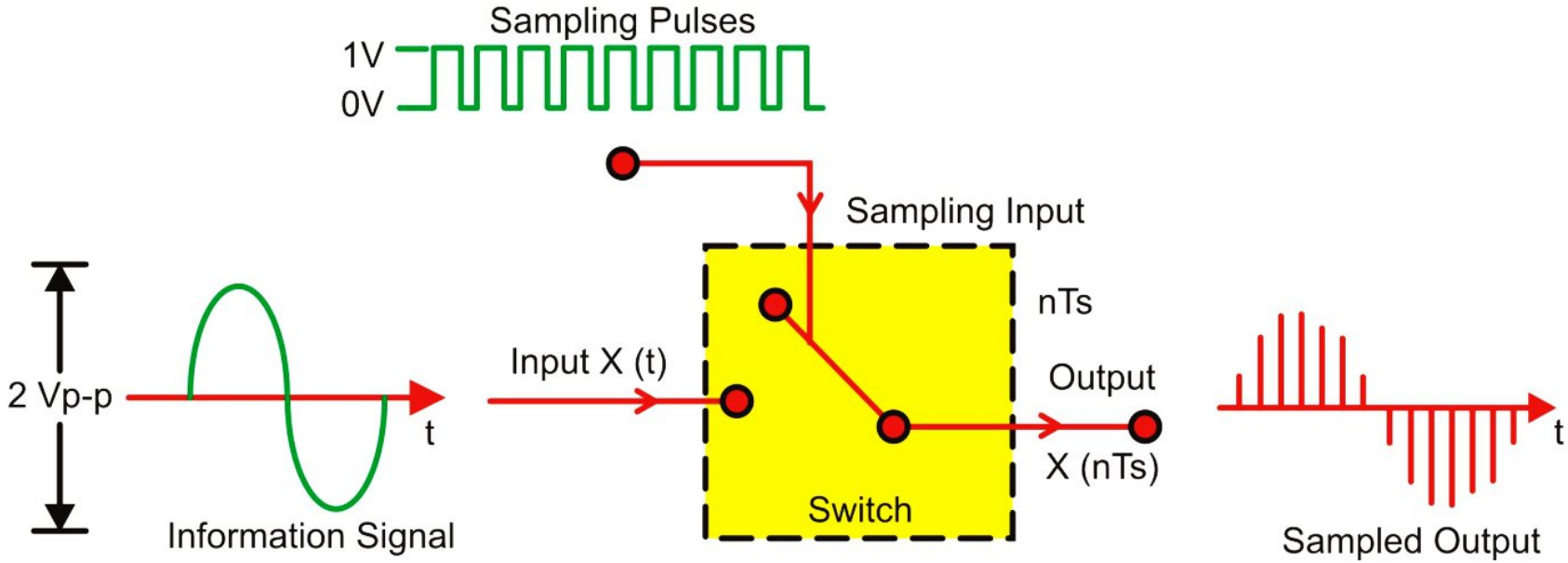


Disadvantages of Pulse modulation over CW modulation

❑ It needs large bandwidth

Sampling means taking several samples from the modulating signal (information or message signal which will be transmitted). From this signal, several samples will be taken to represent the waveform. Sampling is common in all pulse modulation techniques.

Consider an analogue signal ***x(t)*** that can be viewed as a continuous function of time, as shown in figure. We can represent this signal as a discrete time signal by using values of x(t) at intervals of nTs to form x(nTs) as shown in figure. We are "grabbing" points from the function x(t) at regular intervals of time, Ts, called the sampling period.



Basic Sampling Process

Sampling Theorem and Nyquist Rate

Analog signal is sampled every T_s secs. T_s is referred to as the sampling interval. $f_s = 1/T_s$ is called the **sampling rate** or **sampling frequency**. Based on Shannon sampling theorem, minimum sampling frequency f_s should be twice or higher than the highest frequency of modulating signal f_m.

$$f_s \text{ min} \geq 2\, f_m$$

When $f_s = 2\, f_m$ the sampling rate is called **Nyquist rate**. Sampled spectrum is repeating periodically without overlapping.

Original spectrum is centred at $\omega = 0$ and having bandwidth of ω_m. Spectrum can be recovered by passing through low pass filter with cut off ω_m

When $f_s < 2\, f_m$ sampled spectrum will overlap and cannot be recovered back. This is called **aliasing or foldover distortion.**